A NEW SPECIES OF GONATOPSIS FROM THE JAPAN SEA, WITH THE RECORD OF A SPECIMEN REFERABLE TO GONATOPSIS SP. OKUTANI, 1967 (CEPHALOPODA : OEGOPSIDA, GONATIDAE)

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A NEW SPECIES OF *GONATOPSIS* FROM THE JAPAN SEA, WITH THE RECORD OF A SPECIMEN REFERABLE TO *GONATOPSIS* SP. OKUTANI, 1967 (CEPHALOPODA: OEGOPSIDA, GONATIDAE)

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With 4 Text-figures and Plates I–IV

Since SASAKI (1920) established a new genus *Gonatopsis* to install a new species *Gonatopsis octopedatus* SASAKI of the family Gonatidae described on a single specimen taken from near Cape Patience of Karafuto (Sakhalin Island), few informations had long been available for this aberrant group of oegopsidian cephalopods, except for the work of the same author on another new species, *Gonatopsis borealis* SASAKI, recorded from off Hokkaido, Japan (SASAKI, 1924).

Recently, however, this poorly known genus has been furnished successively with two new forms, *Gonatopsis borealis makko* and *Gonatopsis* sp., both found in the stomach of sperm whales caught in the northern North Pacific (OKUTANI & NEMOTO, 1964; OKUTANI, 1967).

During a cruise of the R/V "Mizuho-Maru" of our Laboratory for the tagging experiment with the common squid, *Todarodes pacificus* STEENSTRUP, in the offshore waters of the Japan Sea in summer 1968, an unusual eight-armed squid was obtained together with a great number of the common squid. Very fortunately, this specimen was brought back to the Laboratory in a good condition for close examinations. Later, through the courtesy of Mr. Hiroshi FUKATAKI of our Laboratory, I obtained an additional specimen apparently referable to the same species from the northern region of the Japan Sea in the same year.

The result of examinations of these specimens revealed that they are closely related to the so-called "*borealis*- group" of *Gonatopsis* which, according to OKUTANI (1967), is one of the puzzling groups of all the oegopsidian squids, but are distinguishable from all of the previously known forms by some important characters, such as fin shape and cartilaginous features, that seemingly merit the establishment of a distinct species new to science.

Further, it is supposed with certainty on a photographic evidence that another rare form of *Gonatopsis* lives in the Japan Sea and this form is tentatively referred to

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Gonatopsis sp. OKUTANI, 1967. Thus, it has been revealed that at least three of the five described species of this rather rare genus are distributed in the Japanese waters.

I wish to express my cordial thanks to Messrs. H. FUKATAKI and Shogo KASAHARA of the Japan Sea Regional Fisheries Research Laboratory for their kindness in placing the precious materials at my disposal and their assistances in many ways. Thanks are also due to Mr. Hiroshi OKAWA of the Shimonoseki Branch of the Seikai Regional Fisheries Research Laboratory for his generous permission to use the interesting photographs. Dr. Takashi OKUTANI of the Tokai Regional Fisheries Research Laboratory, gave me many helpful suggestions during the course of this study and kindly read the manuscript, to whom I extend my heartfelt appreciation. I am much obliged to Dr. Takasi TOKIOKA and Mr. Saburo NISHIMURA of the Seto Marine Biological Laboratory, who not only critically read the manuscript but kindly gave me facilities for publishing the present paper.

I. Descriptions of the new species

Gonatopsis japonicus, new species

(New Japanese name: *Nippon-takoika*)

(Text-figures 1–4 & Plates I-III)

Holotype: An immature female in a very fine state; collected with the squid jiggers from the subsurface layer off the eastern coast of Korea at 38°–42.0′ N, 131°-17.3′ E, aboard the R/V "Mizuho-Maru"; at 21:20 on June 21,1968; collected by Mr. S. KASAHARA of the Japan Sea Regional Fisheries Research Laboratory. Deposited at the museum of the Japan Sea Regional Fisheries Research Laboratory (JSRFRL 6801).

Paratype: An immature female partly mutilated; entangled in the surface drift gill net for the pink salmon in the northern region of the Japan Sea at 41°–02′ N, 138°–11′ E; collected by Mr. H. FUKATAKI aboard the R/V "Ariso-Maru" of the Ariso High School, Toyama Prefecture; at 03:30–05:20 on May 9, 1968. Deposited at the same museum as holotype (JSRFRL 6802).

DESCRIPTION

Measurements are made according to the method given by Voss (1963).

Mantle is cylindrical and slender, with parallel sides approximately in the anterior half and tapering gradually to a sharply pointed posterior end. Integument is rather soft to touch, thin but muscular, except for the posterior tip which is gelatinous in consistency. The free margin of mantle is somewhat broadened outward and the greatest width is found here. There is a slight anterodorsal projection on the median line and a shallow ventral excavation terminating in blunt angles on both sides at the

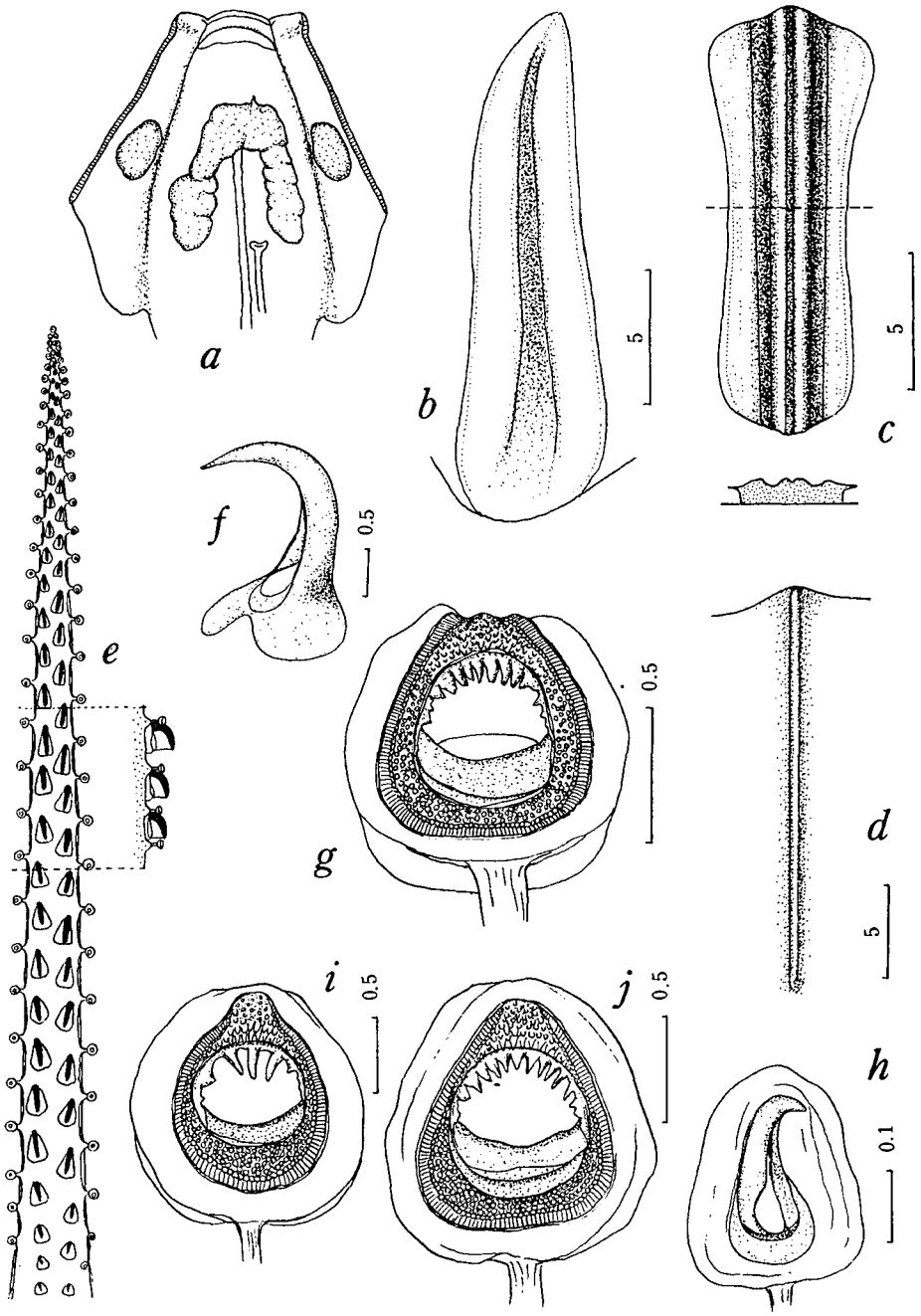

Fig. 1. *Gonatopsis japonicus*, new species. a, funnel organs: b, funnel cartilage; c, nuchal cartilage; d, mantle cartilage; e, diagram showing the arrangement of the armatures on the right dorsal arm; f, hook from the middle of the right dorsal arm; g, sucker from the same; h, hook from the distal portion of the right dorsal arm; i, sucker from the middle of the inner row of the right ventral arm; j, sucker from the middle of the outer row of the same. Scales in mm.

positions of funnel cartilages.

Skin is easily torn off, consequently, the body is almost naked except the mantle free margin and head region where the darkly tinted epithelium remains. Externally a shallow but rather distinct longitudinal groove runs on the mid-dorsum.

Mantle locking cartilages (Text-fig. 1d) are weakly developed, linear and ridge-like, about 21 mm long, and slightly longer than the corresponding funnel cartilages; the posterior tips attain to or beyond the anteriormost portion of ctenidia.

Fin is large, thin especially in marginal portions, slightly longer than width and just half as long as the dorsal mantle length, and broadest at about anterior one-third. Anterior fin lobes are semilunar in outline, slightly projecting out anteriorly beyond the fin base, and curved abruptly at the level of posterior one-third to an acute posterior tip.

Head is short, broader than mantle opening, deeply and distinctly excavated for funnel. Neck is moderately constricted and marked off from the head. Eyes are prominent with a semilunar opening and eyelid bears the sinus in front. Olfactory crests are ill-defined. Funnel is small but rather wide with a well developed semilunar valve inside. Dorsal pad of funnel organ is nearly inverted V-shaped; anterior end is almost straight with rounded corners, and faintly cuspidated near the middle; posterior lobes are rather irregular in shape and their tips reach the anal opening. Ventral pads are almost ovate and 8×5 mm in size (Text-fig. 1a).

Nuchal locking cartilage is elongated, with the anterior tip somewhat expanded,

Table 1. Measurements and counts of *Gonatopsis japonicus*, n. sp.

		Holotype		Paratype	
Measurements:					
Dorsal mantle length		150		166+	
Ventral mantle length		146		158+	
Mantle width		27		—	
Fin length		79		73+	
Fin width		74		83	
		Right	Left	Right	Left
Arm length	I	74	71	102	100+
	II	82	81.5	103	103
	III	78.5	82.5	106	107
	IV	64	66	93	—
Counts:					
Arm armatures[1]	I	67/60	71/60		
	II	73/61	72/59		
	III	71/57	70/58		
	IV	157/ 0	145/ 0		

[1] The numbers of suckers and hooks are expressed by S./H. Numbers of these armatures cannot be confirmed, because of damages done to the paratype.

Table 2. Body proportions and diagnostic characters of 5 described species of *Gonatopsis*.

	G. octopedatus	*G. borealis*[3]	*G. borealis makko*	*G.* sp.	*G. japonicus*
Number of specimens	1[2]	numerous	3 (numerous)	1[4]	2
Mantle length (mm)[1]	**65**	smaller than ca. 250	300–350	230	150–166+
In per cent of M. L.					
Mantle width	**34**	ca. 25	**16**	ca. **39**	**18**
Fin length	**29**	ca. 40	**29**	ca. **43**	**53**
Fin width	**46**	ca. 60	**29**	ca. **70**	**50**
Longest arm length	**85**	ca. 67	**64**	probably, >100	**57**
Head width: Mantle width	<	≧	=	<	>
Fin form	reniform	sagittate	sagittate	rhomboidal or sagittate	sagittate, with an acute extremity
Nuchal cartilage	elongated, very slightly widened cephalad	panduriform, gently constricted near the middle	elongated rectangular	almost quadriangular, with rounded corners. feebly concaved near the middle	panduriform, much widened cephalad, with groove along mid-dorsal
Mantle cartilage	linear, ridge-like, a little longer than funnel cartilage	slender wedge-shaped evenly widened and flattened cephalad	very weak, ridge-like in shape	short rod-shaped	weak, linear, ridge-like, a little longer than funnel cartilage
Arm formula	2, 3, 1=4	3, 1=2=4	2, 3=1, 4	undetermined	2=3, 1, 4
Tentacle	roundheaded insistict tubercle present	absent	absent	remnant present	absent
Suckers on the extremity of arms	in 8–12 longitudinal rows	in 4 longitudinal rows	in 4 longitudinal rows	in 4 longitudinal rows	in 4 longitudinal rows

[1] Measurements on holotype are shown in bold face.
[2] Additional specimens are seemingly collected from the western North Pacific including the Okhotsk Sea (AKIMUSHKIN, 1963).
[3] Holotype is not defined and exact measurements are not given for this species. Although AKIMUSHKIN (1963) reports that the largest size of this species attains about 1.5 m in length, this size seems too large to be referred to.
[4] Two additional specimens probably referable to this have been recorded; one from the Kurile-Kamchatka Trench (OKUTANI, 1968) and the other from the Japan Sea. For the latter, refer chapter II in this paper.

and slightly less than 2.5 times as long as wide; three straight grooves run along the longitudinal axis of the cartilage; the middle one is the least prominent (Text-fig. 1c). Funnel locking cartilages are lanceolate and slightly curved inwards near the narrowed anterior apex; posterior end is stouter and rounded; median groove is very shallow and almost straight (Text-fig. 1b).

Arms are robust and firm in consistency, as long as or slightly longer than a half of the dorsal mantle length, but the ventral arms which are decidedly shorter and only 43 per cent of the dorsal mantle length; arm formula 2=3, 1, 4. All arms are similar in appearance; stout proximally and gently tapering to the attenuated distal tip; cross section is nearly rectangular almost throughout the length, though the integumental webs are formed along the dorso-lateral edges of the 2nd and 3rd pairs; no arms are flattened dorso-ventrally. Umbrella is poorly developed. Arm armatures are quadriserial throughout. As usual in the genus, three dorsal arm pairs are similarly armed with hooks and suckers and the ventral pair is provided only with small suckers arranged in 70–75 transverse rows; hooks are arranged zigzag in inner two rows, while small suckers are arranged likewise in outer two rows; several proximal hooks are smaller and followed by 15–20 pairs of larger ones, and then the hooks decrease in size distally; the number of smaller proximal hooks tends to increase on arms situated dorsally. All these counts mentioned above are shown in Table 2. The outer suckers are supported by a stalk on the small pedicel and almost alike in structure throughout. Horny ring of the suckers possesses 10–15 closely set irregular teeth in the distal half. Protecting membrane is weakly developed through the pedicel bases of respective outer rows of suckers on all arm pairs (Text-fig. 1e).

Buccal membrane is seven-lobed, broad, and furnished with minute crenulations; buccal membrane connectives are composed of seven supports with eight branches, being DDVV-type (Text-fig. 2b)*.

Gladius is penniform, widest just anterior to the middle and at the level very near the posterior end, one-seventeenth of the length in the maximum width (Text-fig. 2a).

Beaks are darkly pigmented, especially in their rostral regions. The rostrum of the upper beak is acutely pointed and with a rather obtuse jaw angle, but the rosturm of the lower beak is inconspicuous. Lateral walls are fragile and become transparent marginally (Text-fig. 2c).

Radula is composed of five teeth in each transverse row; the rhachidian tooth

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* From the taxonomical point of view, positions of the buccal membrane connectives, together with several other characters, are recently reviewed in relation to the family criteria for various oegopsid squids (YOUNG & ROPER, 1968). In this respect, the present species conforms well to *Gonatopsis* sp. of YOUNG & ROPER, 1968, which is the only other form of *Gonatopsis* available to me at present as to this feature. For this coincidence, the family Gonatidae may safely be concluded to be of the DDVV-type. It must be noted, however, that OKUTANI (personal communication of January 4th, 1969) showed me the existence of certain juvenile specimens of *Gonatus fabricii* (LICHTENSTEIN), in which the position of the last ventral connectives can not be defined exactly.

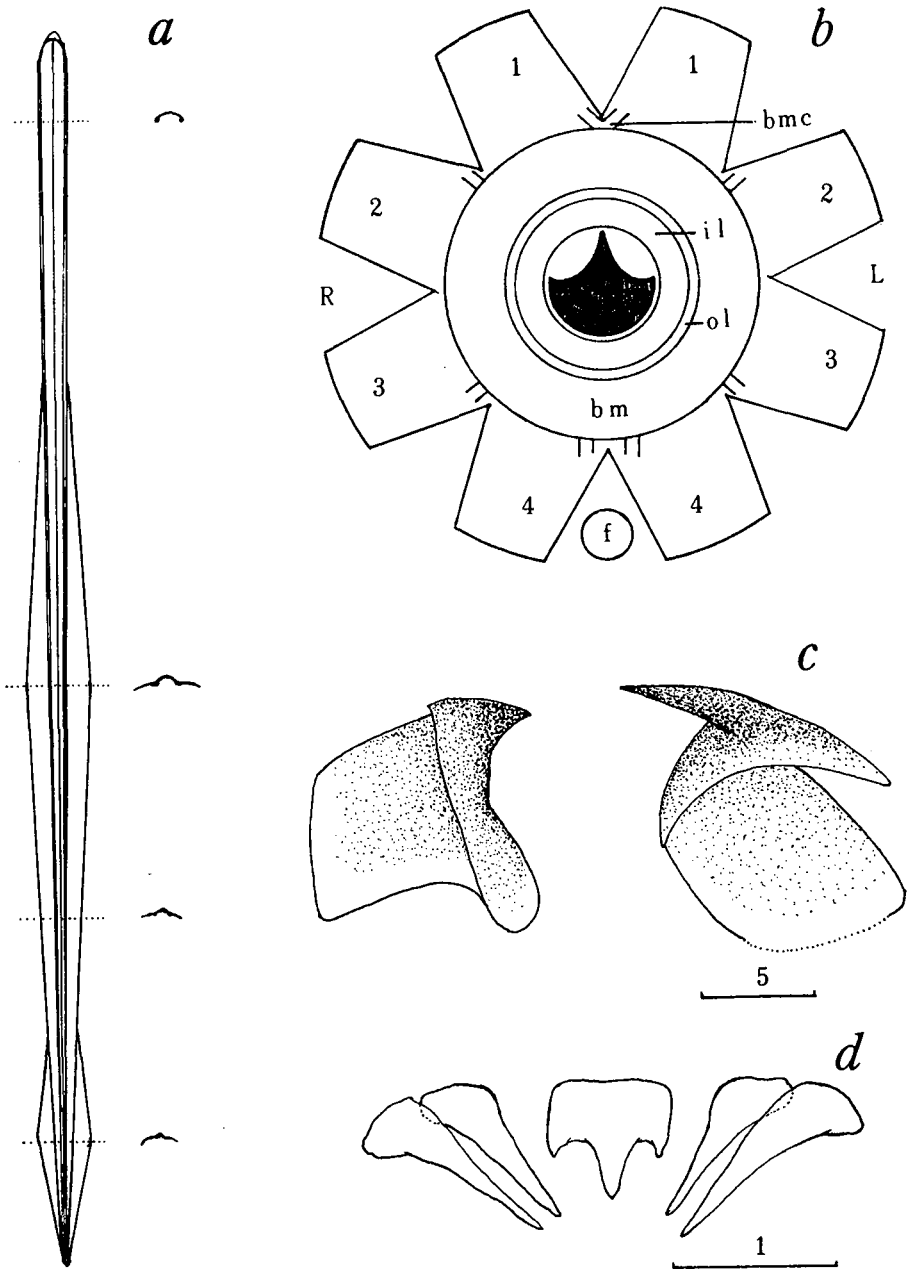

Fig. 2. *Gonatopsis japonicus*, new species. a, gladius; b, diagram showing the arrangement of the buccal elements (il, inner lip; ol, outer lip; bm, buccal membrane; bmc, buccal membrane connective; f, funnel); c, beak; d, radula. Scales in mm.

is tricuspid, the central cusp is much larger than the marginal cusps, and two pairs of laterals are unicuspid (Text-fig. 2d).

As far as I am aware, no particulars are found in its visceral structures. Stomach was moderately filled of food organisms, mostly consisting of an amphipod of the genus *Primno*.

When alive, the body is deep red brown over the whole surface, but both suckers and hooks are faintly tinted with yellow.

Specimens preserved in formalin are uniformly dark red brown on parts retaining the skin.

Distribution: The localities in the Japan Sea of the specimens referred to here are shown in Text-fig. 3, together with the isotherms at 50 m deep which are prepared from the data of the oceanographical observations. At a glance, it is readily seen that both occurrences were restricted within the waters of the lowest temperature less than 2°C, close to the polar front. Furthermore, it seems worthwhile to note that vertical profile of the water temperature at the holotype locality was peculiar in having the reversed thermocline between 75 m and 100 m. This might partly be responsible for the occurrence of this cold-water species at so shallow level; supposition on the property of the fishing gears is that holotype might be captured at the level less

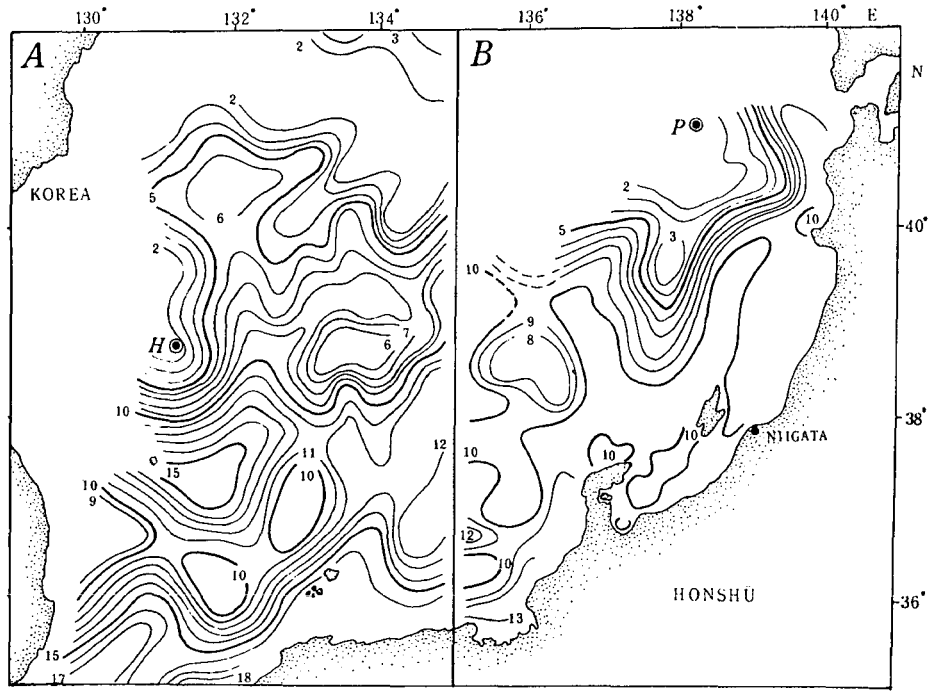

Fig. 3. Localities of *Gonatopsis japonicus*, new species, in the Japan Sea, together with the isotherms in centigrade at 50 meters depth; in the posterior half of June 1968 (A) and in early May 1968 (B). H indicates the locality of the holotype and P that of the paratype.

than 35 m, and the paratype at the level less than 8 m of the water column of more than 2000 m deep.

In a review of the pelagic cephalopod fauna of the Japan Sea, NISHIMURA (1968) listed three species of Gonatidae, viz, *Gonatus magister* BERRY, *Gonatus fabricii* (LICHTENSTEIN), and *Gonatopsis borealis* SASAKI, as being distributed in the deeps of the Sea. However, members of the family Gonatidae which are seemingly particularly prosperous in the northern North Pacific are very poor in number of both species and individuals in this marginal sea, except for the first species mentioned (OKIYAMA, 1965). Besides her southerly situation, the oceanographical and also geographical properties of the Japan Sea may greatly inhibit the distribution of the gonatid squids in that sea. Rather common records of these species including their early larvae in the waters adjacent to the Pacific coast of Hokkaido (SASAKI, 1924; OKUTANI, 1966), seems to support this speculation.

For these reasons, it is assumed that the present new species is a member of the typical cold water squids having their spawning area in some much northen seas, and thus its distribution in the Japan Sea is allogenetic.

DISCUSSIONS

The occurrences of the member of *Gonatopsis* are extremely rare as a whole as compared with those of *Gonatus*. Nevertheless, four species including a subspecies have been described in *Gonatopsis* so far. Majority of them are, however, represented only by one to three specimens. Consequently, the following comparisons are inevitably made merely between the original descriptions and illustrations of respective species. Body proportion and several other diagnostic characters of the five forms of *Gonatopsis,* including the present species, are summarized in the Table 2.

As is known generally, the genus *Gonatopsis* is defined solely by the degeneration of the tentacles with growth. In connection with this, OKUTANI's observations (1966) of some stages of *G. borealis* may be referred to here; tentacles are strong in earlier stages but become poor in advanced stages, so that they are found degenerated externally in the young stages less than 30 mm in mantle length. As seen in Table 2, in some species such as *G.* sp. tentacles never disappear completely even in much advanced stages. Then, as to the phylogenetic treatment of this *G.* sp., special attention must be paid on this character shown in its orginal description (OKUTANI, (1967).

Taxt-fig. 4 presents the growth of fin length relative to the mantle length in respective species, together with some figures illustrating outlines of their actual fin shape. Although the fin shape varies considerably on one hand and enough specimens of serial sizes are unavailable in most species on the other hand, it is clear at least that the present new species is distinct from all its relatives in its fin form with an acute posterior extremity, and also in rather large size of the fin. Fortunately, an

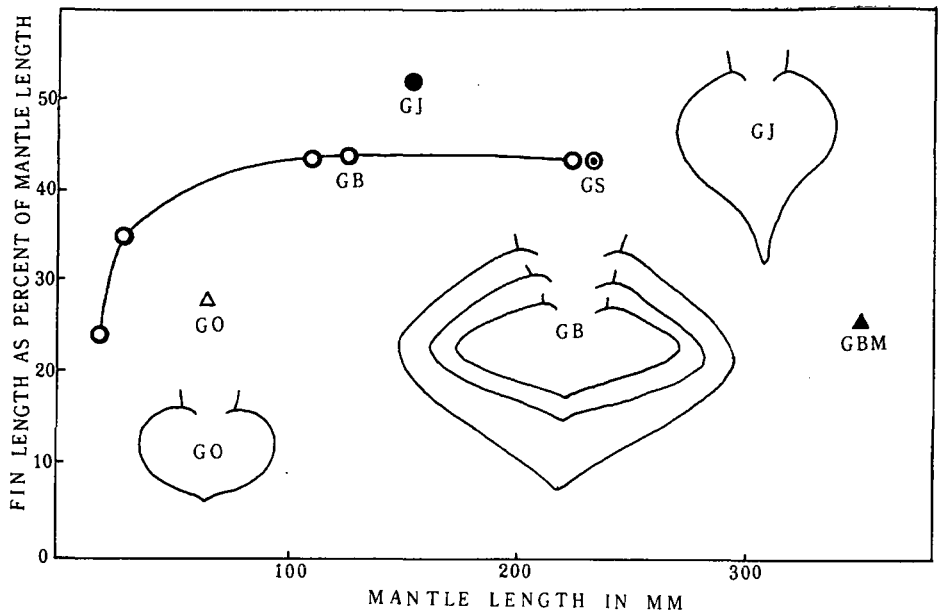

Fig. 4. Fin length of five species of *Gonatopsis* as percent of mantle lenght, plotted against mantle length; together with fin forms of three species. GO, *G. octopedatus*; GJ, *G. japonicus*; GB, *G. borealis*; GS, *G.* sp.; GBM, *G. borealis makko*. In *G. borealis*, 1 and 2 are based on OKUTANI's illustrations (1966) and 3–5 on the SASAKI's (1929).

example of the ontogenetic sequence of fin shape is given for *G. borealis* as seen in the same figure (Text-fig. 4, GB). Moreover, CLARKE (1966) remarked that some near relatives of the oegopsid squids show the similarity in the growth of various body parts including fin, and referred *Gonatus fabricii* to the species group having the longer fin with growth. His remarks may safely be applied to the case of *Gonatopsis* as well, and thus the separation of the present new species on the fin form will be justified for all specimens in other size ranges, which are not known yet. Furthermore, it is very interesting to find that all of the fin shapes of hitherto known species of *Gonatopsis* are exactly represented in the ontogeny of *G. fabricii*, one of the representatives of *Gonatus*, (CLARKE, 1966; OKUTANI, 1966), with its adult homogeny for the present new species. *Moroteuthis* and *Onychoteuthis* belong to the group known to prossess the fin shape similar to the present new species. These may be suggestive of the possible relationships between the above-mentioned genera and also among the forms of the genus *Gonatopsis*.

Other major features to distinguish the present new species are the cartilaginous features such as the nuchal and mantle cartilages. Nuchal locking cartilage of the present new species and *G. borealis* bears a shallow but distinct groove on the mid-dorsal surface, whereas none of the other congeners have ever been known to possess such a structure. On the contrary, the linear and ridge-like mantle locking cartilage

of the present new species is commonly found through the variety of species of Gonatidae, but some species such as *G. borealis* and *G.* sp., which are provided with the structure of different type. In addition, the present new species shows other distinctive aspects as follows: The relative size of the head is the greatest of all species, its width exceeding the mantle width; in other species the former never over the latter (Table 2). The integumentary keels of arms of the present new species are too poor to form the flattened pairs as seen in *G. borealis*. Lastly the radula of the present new species possesses five teeth in each row against seven in *G. borealis* (AKIMUSHKIN, 1963). A similar contrast is also known in *Gonatus*, as five teeth in *G. fabricii* against seven in *G. magister* and *G. anonychus* (SASAKI, 1929; PEARCY & VOSS, 1963).

Probably, the present new species has some close relation to the so-called "*borealis* group" of *Gonatopsis*. OKUTANI (1967) seems to be of the opinion to keep some members of *Gonatopsis* as subspecific forms under polytypic *G. borealis*. I think, however, that the close resemblance between the present new species and some species of *Gonatus*, especially *G. fabricii*, and several unique features of the present new species noted above, may merit the distinctive specific ranking of this new species and at the same time show its special phylogenetic status. Perhaps, the present new species may be accepted as a form related to *G. fabricii*, most closely in the genus *Gonatopsis*.

Summarizing the above-mentioned discussion, a tentative key of *Gonatopsis* is proposed as follows:

1. Tentacle remnants distinct; arms longer than mantle and with rather sparsely beset armatures ..... *G.* sp. OKUTANI, 1967
— Tentacle disappeared completely; arms shorter than mantle and with more or less closely beset armatures 2
2. Arm armatures of distal portion in 8–12 rows ..... *G. octopedatus* SASAKI, 1920
— Arm armatures quadriserial throughout 3
3. Fin clearly shorter than a half of mantle, nuchal cartilage elongated rectangular ..... *G. borealis makko* OKUTANI & NEMOTO, 1964
— Fin nearly as long as or little less than a half of mantle, nuchal cartilage panduriform, grooved mid-dorsally 4
4. Fin distinctly broader than long; mantle cartilage evenly widened cephalad ..... *G. borealis* SASAKI, 1924
— Fin as broad as long, with posterior tip acutely pointed; mantle cartilage linear, ridge-like ..... *G. japonicus* OKIYAMA, new species

II. Record of a specimen probably referable to *Gonatopsis* sp. OKUTANI, 1967

(Plate IV)

During the course of the study of the present new species of *Gonatopsis*, I happened

to obtain two photographs of a fresh squid specimen, which were taken by Mr. H. OKAWA of our Laboratory at that time and now of the Shimonoseki Branch of the Seikai Regional Fisheries Research Laboratory, on board the R/V "Ariso-Maru" of the Ariso High School, Toyama Prefecure, while he was engaged in the pink salmon firshery survey in the northern Japan Sea in spring of 1966. These photographs show respectively the dorso-lateral aspects of the whole specimen on different sides. At a glance, it is almost certain that the specimen is referable to the genus *Gonatopsis*. Very sorry, however, this unusual specimen was neither measured nor preserved, but its flesh was tasted by the crew of the boat after these two pictures were taken and fragmentary observations were made.

The size of the specimen is estimated on photographs approximately at 45 cm in mantle length as compared with the size of deck plates. Although the exact date and locality are unknown, according to Mr. OKAWA's kind information the specimen was caught by long line at the surface in the northern Japan Sea between the North Yamato Bank (the Shumpu Bank) and the Maritime Province of Russia in the late April 1966.

Mantle is cylindrical, somewhat slender, the mid-dorsal of anterior margin well angulated, forming a rather broad protrusion. Fin as a whole is sagittate in shape, shorter than wide, and shorter than a half of mantle. Head is short, a little narrower than mantle opening; neck is moderately constricted; infundibular excavation is deep.

Arms are very long and slender; as along as or much longer than mantle. Ventral pair is seemingly shorter than other pairs of almost equal in length. Integumental keels are well developed in all pairs. Arm armatures are quadriserial, beset more or less sparsely, and arranged roughly in transverse rows at least in the proximal half of the 3rd arms; the larger armatures on the inner side may be referable to hooks and smaller ones to suckers; no further details of the armatures are shown in these photographs.

Tentacles can not be discerned on photographs.

Remarks: Although little can be inferred as to the existence or absence of the tentacle remnants, it may safely be concluded that the specimen is most closely related to *Gonatopsis* sp. OKUTANI, 1967, among the five species hitherto recorded.

Further, according to the crew who tasted the specimen, its flesh was very soft and not so delicious. This reminds us of some diagnostic features of *Gonatopsis* sp. (OKUTANI, 1967). For these reasons, I want to identify the specimen provisionally with *Gonatopsis* sp. OKUTANI, 1967.

It seems that an additional specimen referable to this form has been collected recently from a moderate depth of the Kurile Kamchatka Trench as OKUTANI (1968) reported on the basis of K.N. NESIS's personal information. Thus, this form is considered to be a deep water form, distributing in the northern North Pacific sympatrically with other close relatives. Sporadic occurrence of the present from in the Japan Sea might also be correlated with the hydrological conditions of the sea as

discussed already as to *G. japonicus*.

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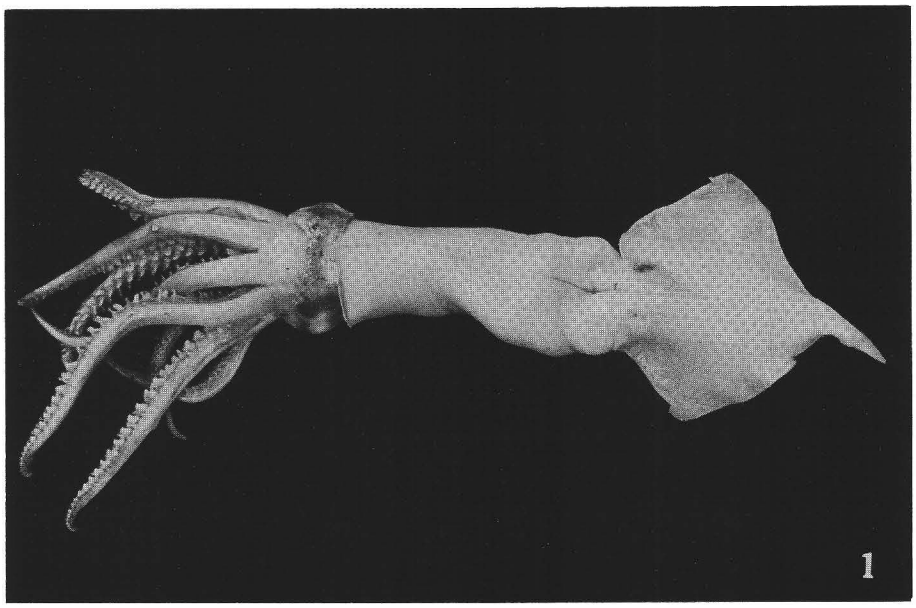
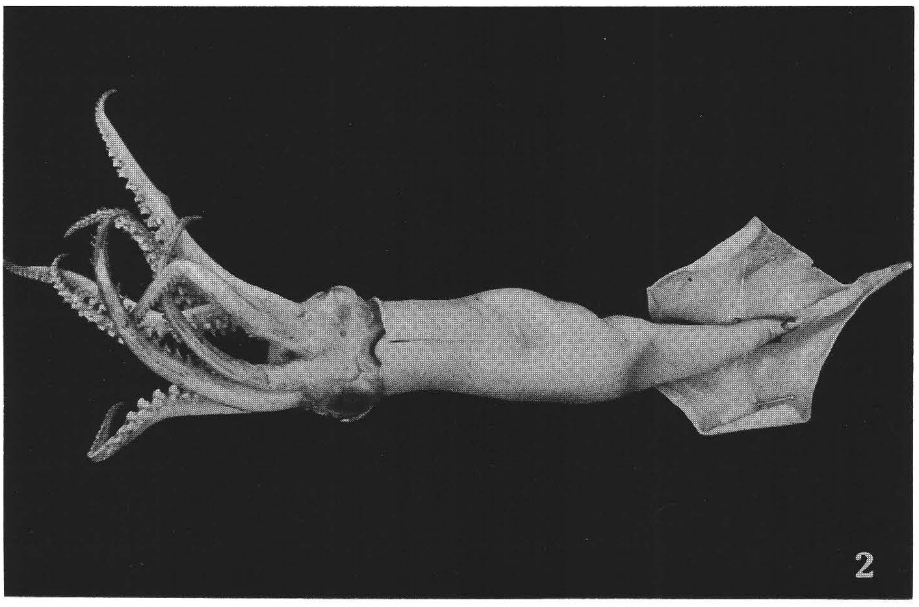
EXPLANATION OF PLATES I-IV

Plate I. *Gonatopsis japonicus*, new species.
Fig. 1. Dorsal view of the holotype.
Fig. 2. Ventral view of the same.
Plate II. *Gonatopsis japonicus*, new species.
Fig. 3. Right side of head of the holotype.
Fig. 4. Ventral surface of arms of the same.
Plate III. *Gonatopsis japonicus*, new species.
Fig. 5. Mantle cut open to show the viscera and locking cartilage of the holotype.
Plate IV. ? *Gonatopsis* sp. OKUTANI, 1967.
Fig. 6 & 7. Dorso-lateral aspects of a rare specimen from the northern Japan Sea. Mr. H. OKAWA Photo.





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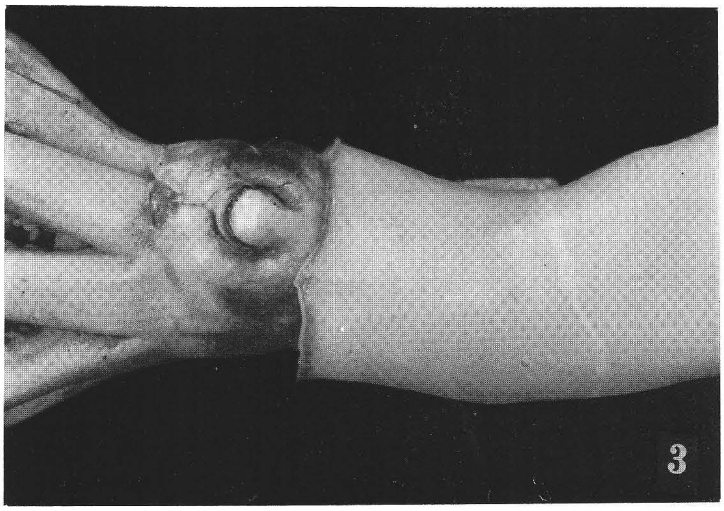

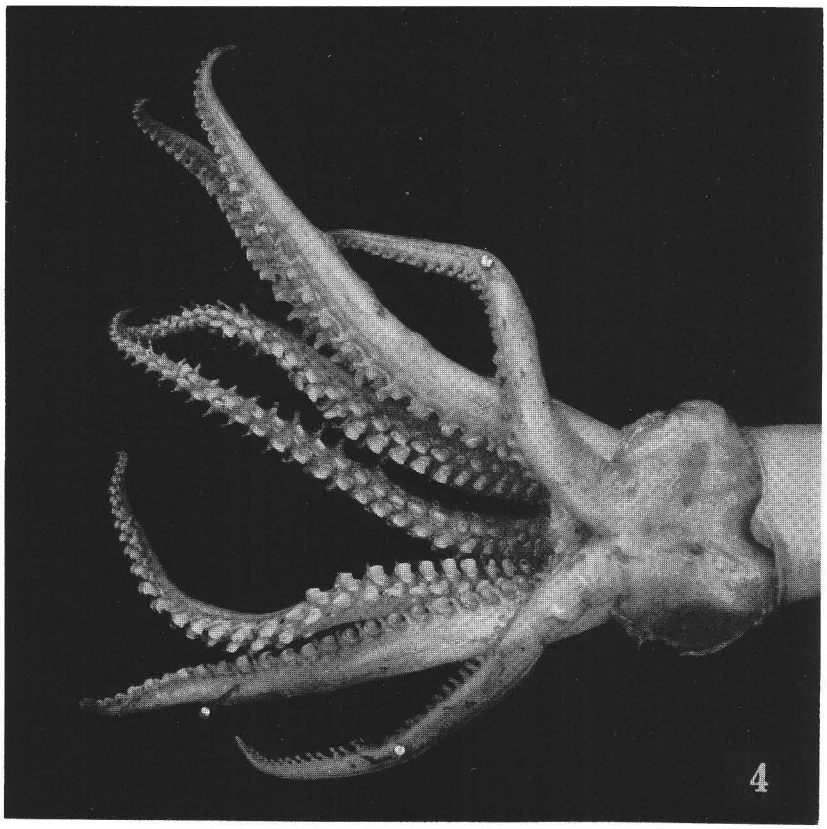

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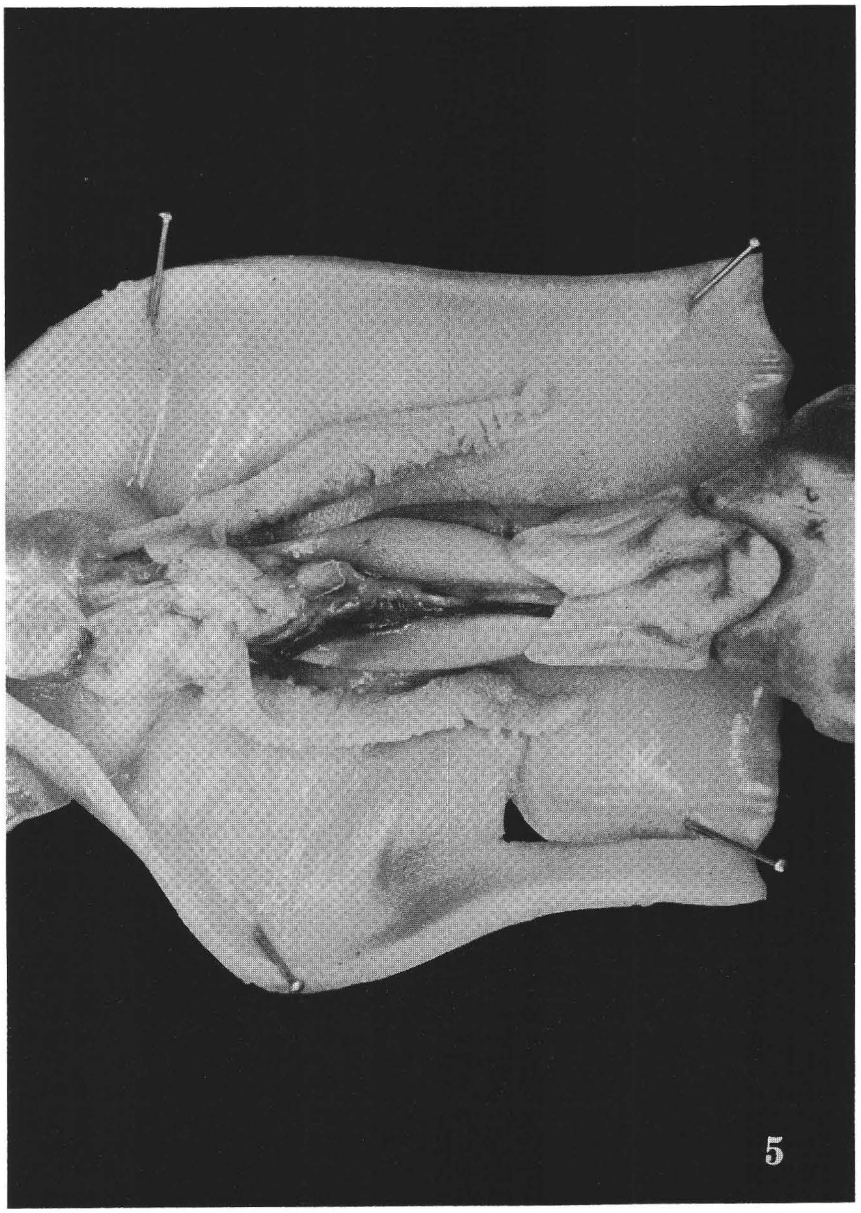

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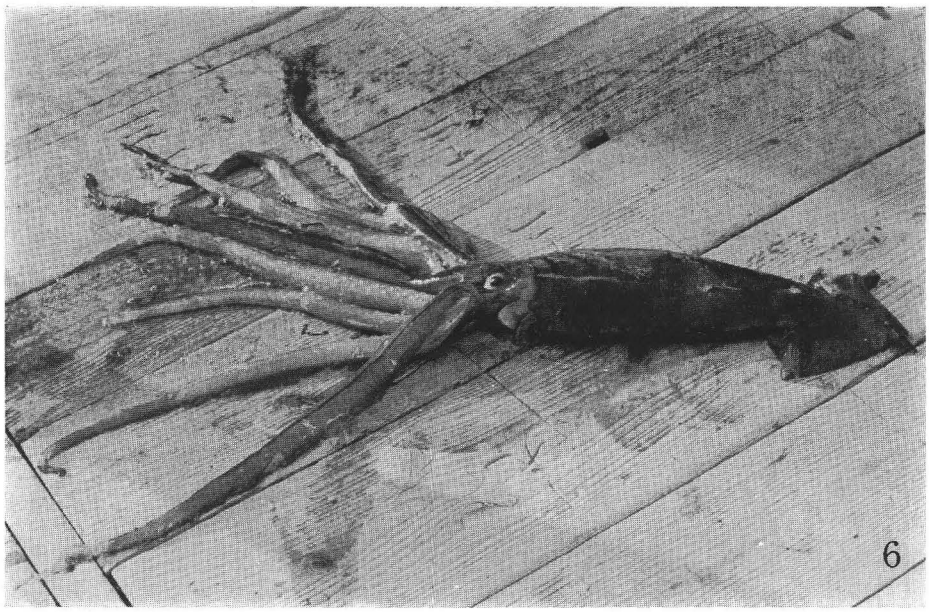
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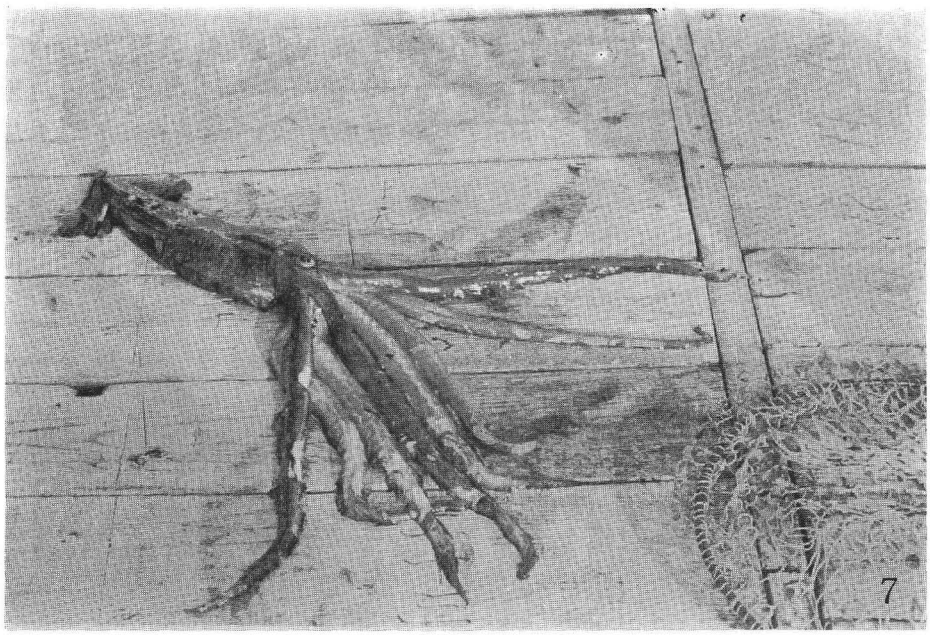
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